Identifying Human and Climatic Influences on Ancient Plant Communities in Dhofar, Oman

Research Thesis

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with research distinction in Anthropology in the undergraduate colleges of The Ohio State University

by

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Abstract

Through identifying changes in plant community changes over time, we can better understand how natural and anthropogenic processes affect vegetation. As climate changes, the natural environment and available resources for anthropogenic use are altered. Human responses to a changing environment include social changes like new settlement patterns or changing family sizes. Consequently, human resource use strategies adapt to these changes, which can have feedback effects on the natural environment. Anthropogenic influences and human presence in a landscape are identifiable through the variations of plants present, which we can measure using vegetation proxies. Our research uses plant fragments found within fossilized midden deposits of desert rock hyraxes (*Procavia capensis*) to study anthropogenic vegetation changes in Dhofar of Oman over the past 3,500 years BP.

The hyrax is a small herbivore that grazes in close proximity to its den, so that hyrax middens reflect localized vegetation. From 45 middens samples, we extracted identifiable macrofossils. We used incident light microscopy and a digital camera to compare specimens with modern reference material. We relied on radiocarbon ages from 33 of the 45 middens to understand the temporal shifts of vegetation patterns. To grasp what past vegetation was present in the landscape, identified fragmented macrobotanicals were weighed and analyzed for the presence of 5 particular “indicator” species of anthropogenic activity. The “Indicatory Species Approach” identifies particular plant communities present indicative of human’s presence in a landscape.

Through statistical analysis, we recognized many distinct types and categories of species that provided quantifiable proxies of desert vegetation while we also analyzed the ability of the middens to capture anthropogenic activity. We conducted a canonical correspondence analysis (CCA) and detrended correspondence analysis (DCA) for 89 identifiable fossilized botanical species specimens in 45 different locations. The results from the DCA suggested that the vegetation developed as an adaptation to more arid climates. For the CCA, the variables, which are a) distance to human monuments and b) distance to fresh water, explained 26% of the species variation. This result suggested that plant assemblages are influenced by human pressures.

Key Words
paleobotany, anthropogenic indicator fauna, Dhofar, pastoralism

Introduction

By observing temporal changes in vegetation, we can better understand how natural and anthropogenic processes alter vegetation. Human responses in pastoral societies, to climatic and environmental changes in arid environments, may include changes in group size, territoriality, pastoral practices, which in turn alter vegetation through human shifts in land-use pressure or resource choices. Tracking such changes is a scientific challenge. This project uses the fossilized botanical record found preserved in the hyrax midden deposits to document ancient vegetation and evaluate the impact of past humans on the assemblage's spatial and temporal variation.

Some regions have abundant paleo-proxy data on ancient ecosystems. Southeastern Arabia, Dhofar, hyperaridity and monsoons season pose challenges for fossil preservation. The seasonal monsoon in this region creates pockets of vegetation in the valleys leading towards the Rub' al Khali, Arabia's largest desert. Humans have long inhabited these arid landscapes, yet their long-term anthropogenic impacts have been difficult to disentangle from the effects of climate change (Lézine et al., 2007; Parker and Goodie, 2008).

Pollen and macrobotanical analysis of faunal remains retrieved from fossilized desert hyrax (*Procavia capenis*) dung build complementary proxy records needed for vegetation reconstruction and taxonomic resolution. The assemblages provide a temporal and spatial understanding for the types of species present in past environments. This paper is an attempt to examine anthropogenic flora indicators within the hyrax midden macrobotanical assemblages to identify the human presence in the environment, recognizing that hyrax midden macrobotanicals offer an important complement to other proxy records.

Literature Review

Humans and plant's symbiotic relationship is undeniable. To understand the ancient world pastoralists lived in, understanding what plants humans accessed is critical. Reconstructing the landscape vegetation throughout time allows researchers to understand better anthropogenic effects humans have on the environment. This research examines the assemblages of fossilized macrobotanical remains found within hyrax midden deposits to assist in determining whether humans were a presence in the environment and, ultimately, to detect anthropogenic pressures.

Due to the lack of lakes in southern Arabia, most specifically in Dhofar, Oman, there are no continuous paleoenvironmental records of ancient vegetation after 8000 BP, let alone vegetation indication of human use (Lézine et al., 2007). Human presence is challenging for archeologists to isolate from the landscape when little material culture remains. Agricultural societies tend to leave behind archeological remains of food storage structures and long term ecological changes through systematic cropping. Pastoralists' nature of mobility limits the quantity of material culture they can carry (Buffington and McCorriston, 2018). Paleoenvironmental records are critical when isolating the effects pastoralism had on the ancient environment.

Study Area

Dhofar is located on the southern margin of the Arabian peninsula, situated in modern-day Oman. The landscape is unlike any other in Arabia. Upon flying in upon Dhofar's largest city, Salalah, one can look down and see the abrupt changes in the landscape. The region is divided into four main environmental cross sections, each with unique plant life (Miller and Morris 1988).

Closest to the Indian Ocean is the region of the coastal plain. The coastal plain is sparse in plant life apart form a few banana farms near the larger city. The coastal plains' vegetation is commonly characterized by low sub-shrub and grass coverage, creating the beginning of a biodiverse landscape transition. The coastal plain rolls to the prominent steep plateau region, known as the escarpment.

The escarpment consisted of dense woodlands and lush foliage at particular times of the year. *Anogeissus dhofarica's* cloud forest dominates in mesic environments between 100-1000 m (Ball 2019). Locals still recall the forest's brush being so thick that camels could not enter to graze. Plant taxa like *Ficus saclicifolia, Commiphora spp., Acacia spp.* cover the region providing woods for the pastoralists (Miller and Morris 1988). The escarpment has plentiful woodlands at lower altitudes reaching up towards 500m.

The dry plateau marking the continental divide lies inland from the escarpments transition. The plateau is denuded, with minimal foliage and topsoil. *Euphorbia balsamifera* and *Commiphora spp*. dominate the region, while limestone rocks and short grasses make up the landscape. The dry plateau flattens out into Nejd, the most arid of all the four zones. The foliage found within this region has adapted to the arid environment and lack of constant ground water, like *Euphorbia cactus* and *Aloe spp*. (Miller and Morris 1988).

Over the past 6,000 years, paleoclimate data has shown the region has not had a stable climate. The region faced a quickening moistening period between 300 BCE – 300 CE (Fleitmann et. al. 2007) and a dramatic aridification event occurring 4,000 B.P. (Miller and Morris 1988, Cullen et. al. 2000, Preston et. al. 2011). Due to the placement of the region at the northmost edge of the Intertropical Convergence Zone, the summer in Dhofar is privy to cool winds blowing east from the Indian Ocean (Ivory & Lézine, 2009). The orographic effect of the mountain range precipitates the water molecules found within the onshore wind to collect and produce a dense fog, known as the *khareef* (Preston et. al., 2011). The vegetation endemic to Dhofar has adapted to the summer *khareef's* heavy moisture followed by the long arid period (Miller and Morris, 1988).

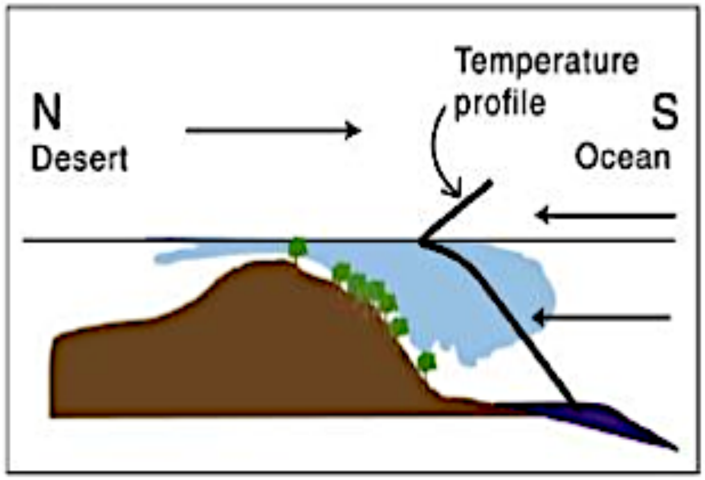

Figure 1 (McCorriston et. all 2018) The monsoon season, or khareef, formation process in Dhofar, Oman.

Hyrax Middens as a Preservation Method

The rock hyrax (*Procavia capenis*)–a small, shy herbivore– has become a crucial factor for researchers to develop paleoenvironmental archives for arid environments (Carr et al., 2016). Due to the small scavenging range of the hyrax, a localized sample of the vegetation is presented in the midden assemblages. The hyrax is a herbivore that grazes on the local vegetation around its den, preferring leaves, stems, and fruits. This study assumes that the hyrax has not changed its eating behaviors over the past 6000 years BP, with preferences in plant foods near to its den.

The hyrax is known to urinate and defecate habitually in the same location. The lack of environmental moisture makes the urine evaporate quickly, crystallizing into an amber-like substance. The precipitating salts seal the organic material within the now-fossilized middens. Preservation in stratigraphic layers preservation is common within the rock crevices, with younger material on top and older organic material on the bottom. The hyrax den is located within small limestone, karst channels that run through the wadi valley's wall. The labyrinth of pathways that make up the den also protects the hyrax from extreme sun exposure and predators, like the Arabian leopard.

This assemblage is analyzed through pollen samples and macrobotanical remains to develop a sense of best taxonomic resolution for paleo vegetation (Gil-Romera et al., 2007). The organic fragments are then able to be recovered and analyzed by identifying the plant fragments to the genus or species level and quantifying these observations (Gil-Romera et al., 2007).

Researchers from the University of Witwatersrand in South Africa have used hyrax middens found within the arid climates of Southern Africa to reconstruct the vegetation of southern African savannas. They were able to conclude that hyrax midden preservation is a "valuable tool in unraveling regional paleoecological dynamics in a region where grasses are frequently over-represented within the pollen spectra (Carr et al., 2010)". However, to date, there has been little work looking at how these hyrax middens may capture anthropogenic flora indicators or organic materials which are known to be present after human presence. Therefore, our project has the potential to add an entirely novel and potentially powerful tool to our understanding of the Anthropocene and its history in desert ecosystems.

Pre-history Anthropogenic Flora Impact

Human and animal occupation in a region impacts the variation and frequency of species present. Humans are incredibly adaptable to a variety of different climates and biomes through the leverage of culture. Arid and hyper-arid environments, like that of the Nejd, create a unique set of opportunities for pastoral occupation; grassland is plentiful. Human occupation in the southeastern region of Oman is categorized by three major periods beginning in the Neolithic. This was concluded through comparative research of lithic material from Eastern Arabia and other regions of Oman. The earliest arrowhead are dated through similarities of lithic seriation in regions of Saudi Arabia and Yemen (Crassard 2008, Charpentier 2008), to the 7th or 6th millennium BC. Thus, the serration suggests human migration through the Dhofar and Rub' al-Khali during this period

The peoples who inhabit the region of Dhofar historically practiced pastoralism. Pastoralists, by nature, leave behind little material culture, thus providing a problem for archeologists to reconstruct past occupation and migration patterns (Buffington and McCorriston, 2018). Instead of investing in a durable material culture which would be preserved in the archaeological record, the wealth of pastoralist lies within their cattle, which provides resources for the herder household.

Vegetation is foundational to humans lifestyles all around the world, from cultural relations to substance. Pastoralist's appreciation and integration of the vegetation is apparent, partially due the subsistence grasses provide to their cattle. Humans' economic choices, social relationships, and cultural practices can place stress on the environment's resources, indirectly and directly affecting the vegetation. For vegetation is a critical environmental component, cycling water through the atmosphere and producing oxygen. By understanding the relationships between past human-vegetation interaction we can strive to better understand human's role in past climate change processes.

In the archeological record, monuments and burial sites are some of the only material culture archeologists have to reconstruct pastoralists' presence. Monuments in the region took many forms from boat shaped graves to upright tumulus (see figure 2). These monument sites are built with stones often repurposed from previous monuments. The stones are so large they require multiple families in construction, thus requiring many families to connect and mutually invest resources (McCorriston 2011, Harrower et. al 2014). The sites act as a landmark for social cohesion allowing for groups to meet, exchange resources and marriages in a somewhat isolating and mobile life. Sacrifice and meal preparation indicators are found within these sites. These attributes highlight the importance of the cattle herds for food. Moreover, the sites act as community gathering spots for many families (McCorriston, 2011). Through archaeological survey, monuments and burials are identified to show the human presence in the landscape. These archeological sites are signifiers for human-environmental interaction.

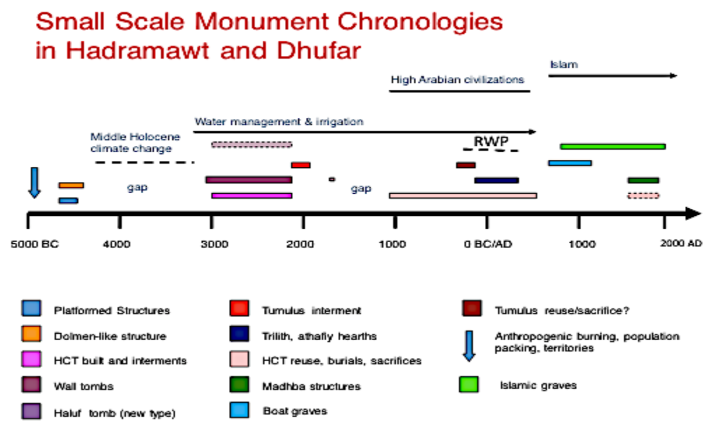

Figure 2 Human presence timeline within Dhofar, Oman.

McCorriston et al 2008:RASA-AHSD Projects in Yemen and Oman; Crassard & Hitgen 2007, 2010; Zarins2010;

Prior anthrocological studies of the sites' hearths, charcoal assemblages exhibited the appearance of specific species, like *Acaica tortilis,* resulted from human activity within Dhofar (Buffington and McCorriston, 2018). Through an ethnobotanical understanding of Dhofar, the fossilized macrobotanical remains can begin to clue in researchers on the impact past humans had on the vegetation. Anthropogenic indicator species documented through previous studies can assist in understanding the human's influence of climate change.

A wide variety of vegetation is actively sourced from pastoral communities, from grazing animals to harvesting woods. *Ziziphus leucodermis* served as fodder during the dry season (Miller and Morris, 1988). *Acacia tortilis,* as a crucial leafy tree, is used by pastoralists as protein supplements for cattle during the dry season. *Acacia spp*. are noted for use in pastoral roofing for houses and animal enclosures (Miller and Morris, 1988; Janzen, 1986). *Commiphora spp.*'s wood is leveraged as a strong building material. The tree also holds cultural importance by providing harden sap, known as myrrh, which is sold on the market (Lupton et al., 2012). *Commiphora myrrha* and *Boswellia sacra* harvested by pastoralists for their cultural significance could have created an economic relationship between pastoralists and coastal cities.

Dodonaea spp. is unpalatable to livestock, allowing *Dodonaea spp.* to grow more prominently in grazed lands. *Dodonaea spp*. are indicators in the assemblage for possible overgrazing (Morris, 2001). EUPHORBIACEAE has a wide range of medical and veterinary uses practiced by pastoralists. It is one of the largest species families in Dhofar for it contains numerous genera and species found within the region (Morris, 2001). A change over time in the frequency, location, and abundance of these species in modern plant communities can clue researchers into the impact of human activity. Figure 3 shows a map of Dhofar with both archeological and hyrax midden sample sites. The hyrax middens offers a localized assemblage of vegetation associated with these archeological sites, which would otherwise not be available.

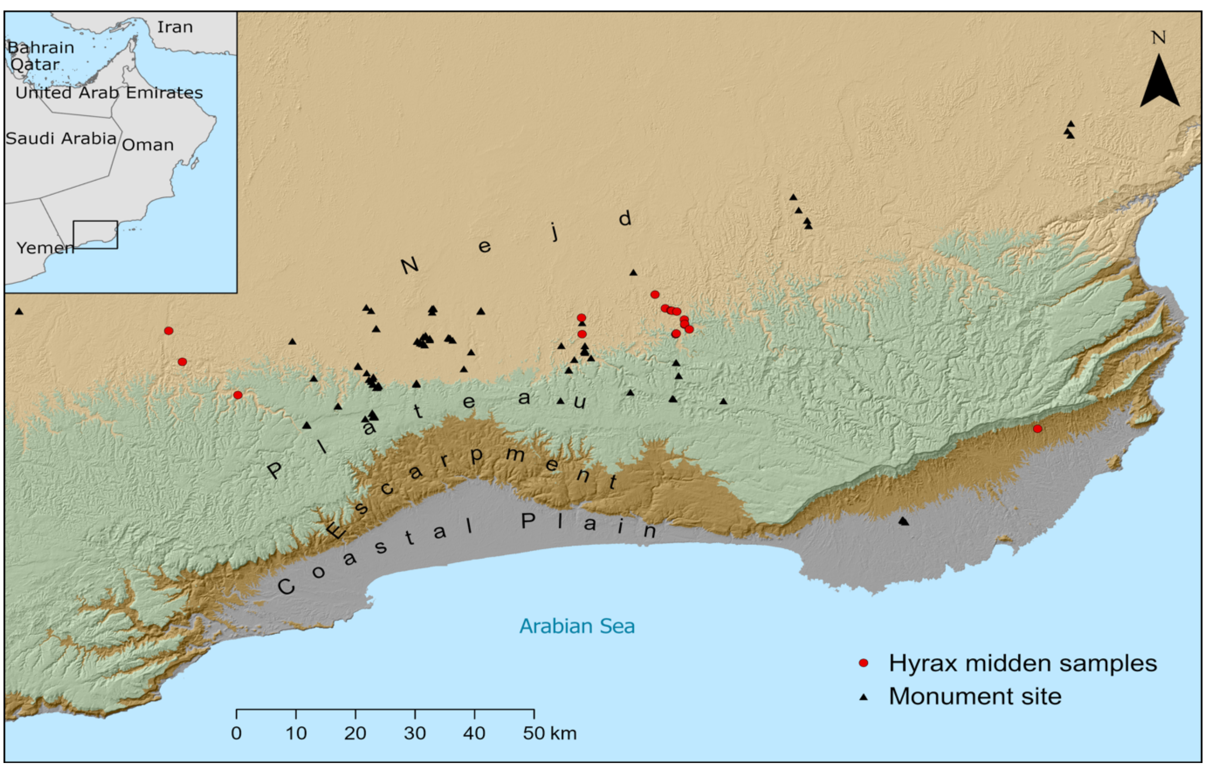

Figure 3 Map of Dhofar: Exhibiting Archaeological Sites and Midden Sites

Hypotheses

This study will test that the hyrax midden assemblages are a viable proxy for vegetation change and indicate human activity within the environment. By using the "indicator species approach" the following five species are modern species which have the same ecological tolerances as their not-very-long-ago con-specific forebears (Miehe et al., 2009; Gaillard, 2007).

Hypothesis one tests macrobotanical proxy data's ability to show vegetation at different points in time and space that are implicitly driven by local climate. Hypothesis one will be tested through the site-species specific data analyzed with a detrended correspondence analysis (DCA) to understand the significance between species (DCA). The DCA will illuminate difference between weight abundance for each species in relationship to site data.

My second hypothesis explores the connection between the vegetation assemblage shifts and human activity in the region. This study tests that macrobotanical assemblages capture indicators species of human activity within the Dhofar over the past 3500 BP. A canonical correspondence cnalysis (CCA) will analyze the distribution of species in relation to site specific constraints. The species were constrained along four main environmental factors: radiocarbon date, latitude, distance freshwater spring and distance to human monuments.

Table 1. Anthropogenic Indicator Species

Indicator Species	**Economic Use**
Ziziphus leucodermis	used as fodder for dry season (Miller and Morris 1988)
Commiphora spp.	commonly known as myrrh, strong building material and holds cultural importance through the myrrh's sap (Lupton et. al 2012)
Acacia tortilis	a crucial leafy tree needed for protein supplements during the dry season (Janzen 1986)
Dodonaea spp.	indicator of overgrazing (Morris 2001)
EUPHORBIACEAE	wide range of medical and veterinary (Morris 2001)

Table 1 identifies the indicator species used within this analysis and the species' economic use to pastoralists. A strong relationship between these specific ethnobotanical species to anthropogenic environmental factors sites can suggests anthropogenic activity within the environment. Through comparison of the botanical data to climate-environmental factors and anthropological/archaeological-environmental factors within the CCA, we can begin to disentangle the effects of human activity from climate factors on hyrax assemblages variance.

Methods

We collected 46 testable midden sites from the Dhofar, Oman during three field seasons: Spring 2017, Spring 2018, Autumn 2018. Each field season was devised alongside the archaeological and geomorphic surveys completed by the interdisplinary Ancient Socioecological Systems of Oman. No previous hyrax midden surveys were conducted in the Dhofar, however, preliminary surveys of packrat middens were conducted in ecological studies in Yemen. Therefore, a new systematic survey method was implemented to identify possible midden dens.

Surveys to find hyrax sites were conducted with guidance from regional Omani Minister of Culture representatives who knew the land and would assist the hyrax team in spotting potential hyrax dens. The majority of middens were collected from Wadi Dhahabun and Wadi Ghadun. The survey method identified the northern, most-arid sector of the Wadi Dhahabun, beyond the belt of frankincense trees. The belt of frankincense trees within the wadi is often associated with the limit of khareef moisture. Therefore, beyond these arid zones, Dr. Ivory found fossilized middens were abundant and easily located (ASOM Hyrax Field Report 2018).

The hyrax survey would begin each day early in order to avoid the strong heat of the afternoon. Breaking up into pairs, the hyrax survey team would explore cross-sections of varying wadis in search of hyrax dens. Upon identifying the hyrax den, visible from their trails of deposits falling from and staining the wadi wall, the field team would reconvene and approach the site as a collective to assist in removal of the midden. The team would carefully chisel and remove the hard, hyrax midden. Throughout the seasons, the hyrax team observed harder middens received the oldest 14C dates. Geographic coordinates were collected for the midden. The midden deposited would be bagged and labeled, identifying the top and the bottom for stratigraphic dating purposes. These middens are representative of distinct vegetation assemblages for fifty meter radius from the site.

In the lab, the whole middens were weighed and dissolved with 2 L of room temperature water. The samples sat in the buckets for one week. The contents of the buckets were stirred daily to assist in breaking the solidified masses down. The samples were then sieved through 500 micron screen and subsequently dried and weighed to extract both the fecal pellets and the organic material. Specific samples of 10 fecal pellets were sent to the University of Georgia Center for Applied Isotope (CAIS) for radiocarbon dating. 14C dates were extracted for 33 of the 46 middens. The 14C dates for plant fossils was used to create a proxy record of time for vegetation assemblages to be compared. All samples were calibrated using OxCal. 3.9 and are reported in calendar years before present.

After receiving the disaggregated midden, we recorded the volume of physical matter, sift for size separation, and then record the volume of each of the sizes (2mm, 1mm, >500mm, >250mm). The whole midden after disaggregation would be comprised of a mixture of rocks, pellets, and macrobotanical remains. We physically sorted and grouped the organic material from inorganic material by each size class for easier visualization and identification of the botanical fragments. The sorting of botanical remains from pellets and rocks involved the immense help of fellow undergraduates, Alyssa Deever and Jackie Stewert.

Through the use of incident light microscopy and a digital camera, modern reference material was compared to the fossilized specimens and unknown specimens were documented into types. Through previous projects of organizing the Arabian herbarium, in respect of genera-family phylogenetic evolution, I acquired a thorough understanding of south eastern Arabian species morphology. After the identification of the fragmented macro-botanical plants into species and types, we visited the Oman Botanical Garden to sample additional reference material for comparison.

We accompanied botanists from the Oman Botanical Garden as they surveyed the regions where our samples were gathered, Wadi Dhahabun and Wadi Ghadun. The surveyed assessed the modern day landscape and collected the additional reference localized material for the herbarium used for unknown type comparison assessed the past vegetation of the region. Oman botanists, Dr. Tony Miller and Dr. Annette Patzel, reviewed unknown specimens and assisted in identification of many of the plants including *Cocculus pendulus, Lindenbergia indica, and Ficus spp.*

Following identification, weights of each species group within each sample fraction was collected. The weight of each specimen group was then calculated to find the percentage of that specimen within the overall sample, as well as the percentage of the total identifiable plant matter within the sample. The weighted abundances are instrumental for the analysis.

Analysis

Statistical analysis conducted using the weighted abundance of each species within the assemblage analyzed the vegetation variation. Many environmental variables impact the ecological data ranging from climatic occurrences to varying precipitation levels. Thus, the species assemblages present resulted from many taphonomic pressures.. Statistical analyses reported here include ubiquity of species, Detrended Correspondences Analysis (DCA) and Canonical Correspondence Analysis (CCA)

Ubiquity or the presence analysis is a common strategy used by paleoethnobotanists to to control for preservation factors. Ubiquity allows for one taxon to be observed independently from other. The analysis looks holistically at how frequent the species occurs throughout the landscape (Hastorf and Popper 1988). Particular attention was made to assure species were grouped through clear morphological similarities to ensure each taxon receives equal weight in analysis .Due to the poor preservation of botanical remains, it is important to use ubiquity to understand the frequency in which species appear in our assemblages.

Several vocabulary terms are critical to understand for discussion of the DCA and CCA analyses. “Species” refers to the macrobotanical fragments which have been collected and group into biological taxon.. Sites refer to the collection site of the hyrax midden. Location, midden age, and other variables are environmental variables by which I mean potential constraints on relative abundances in my dated midden assemblages.

The CCA and DCA for this study were processed through Rstudio (RStudio 2015). The analysis required packages ‘vegan,’ ‘PerformanceAnalytics,’ and ‘dplyr ‘ to assist with analysis. ‘Vegan’ includes tools to describe ecological data in community or site groupings (Oksanen 2015). ‘PerformanceAnalytics,’ traditionally an econometric tool in Rstudio, was advantageous to use in our analysis because it created a chart correlation, showing the relationship of our variables in relation to each other (Econometrics 2020). The 'dplyr' package controls for data manipulation when formatting the DCA and CCA figures (Wickham et. al. 2018).

Detrended Correspondence Analysis (DCA) was developed from Correspondence Analysis (CA) to overcome CA shortcoming's analyzing redundancies in multivariate datasets found frequently within ecological studies (Oksanen 2015). The species included on the biplot must reach the threshold of being present in 5% of assemblages to appear on the DCA. This reduces noise to aid in interpretation. DCA was applied to the botanical assemblages to identify any trends species relationship to sites over time.

The second analysis conducted on the data set, Canonical Correspondence Analysis (CCA), assesses whether patterns can be explained by constraining environmental variables (Ball 2019).The species included on the biplot reached the threshold of 1% presence in the assemblages, reducing noise to aid in interpretation. Four variables used in the CCA to constrain the species-site variance radiocarbon date, latitude, a distance of midden site to freshwater spring, and distance to human monuments.

CCA Environmental Variables

For each environmental constraint, I chose to test its effect on the variance of species composition across the different assemblages, including the effect of anthropogenic pressure on ambient vegetation. The 14C dates were collected from 33 of the 45 middens, calibrated to BP using the Oxcal 3.9 program online (https://c14.arch.ox.ac.uk/oxcal.html) and entered within the spreadsheet, substituting 0 as a value for "modern-day" dates and NA for missing data. The time constraint allowed for species variance to be understood temporally. Radiocarbon determination can be found at the back of the paper, in Appendix C.

Geographic coordinates were collected at each midden site during data collection. The coordinates produced a spatial understanding of the site landscape's relationship with species. By using latitude as a constraining environmental variable, the CCA tests whether the distance to the Indian Ocean and the other environmental regions significantly explains variance in midden-species assemblages.

Immense support and guidance was contributed by Dr. Lawrence Ball in the generation of environmental variable proxy records. Ball's development of modern-day geospatial datasets of Dhofar produced complementary freshwater spring geospatial dataset (Ball 2019). The human monument data was generated from the Ancient Human Social Dynamics (AHSD) Project through archaeological surveys conducted in Hadramawt and Dhofar (2009-2013) (Harrower et. al. 2014). Proximity tools within ArcGIS Pro allowed for the analysis of data from both data 20 sets to hyrax midden sites. The data sets for each constraint per assemblage are located in Appendix C

Human monument data is the most definitive indicator we have of people's past presence in the environment. By extracting distance from these previously recorded monument sites to the hyrax sites, using the same methods as for springs, we were able to examine species responses to proximity to past human presence. Freshwater is a necessity for all human and animals, often shaping the plant life around. Therefore, the distance between hyrax sites to freshwater presents itself as a viable environmental constraint. The distance of freshwater to the hyrax site may explain the site-species relationship we see in the DCA. We assume in this study that freshwater spring locations have remained continuous for the past 6,000 years (Ball 2019).

Results

Presence of Species

Across the 45 samples sorted, the five indicator species were present in the assemblages. Table 2 describes the five indicator species' ubiquity. *Ziziphus leucodermis* was present within 26.5% of all samples. *Commiphora spp*. was present in .05% of all sites, making it the least relevant indicator species within our assemblages. *Commiphora spp.* are dated on average 706 years BP. *Acacia tortilis and Acacia spp.* were present in 64% of assemblages, placing *Acacia spp.* as one of the most dominate genera within the assemblages. *Acacia*-rich samples have dates that range from modern material to 4013 years BP. *Dodonaea spp.* is present within 9% of samples, dating from current day to 3500 years B.P. The family EUPHORBIACEAE is present within 22.2% of the samples collected. EUPHORBIACEAE dates range from modern day to 1500 years BP.

Indicator Species	Ubiquity	Percentage of all samples
Ziziphus leucodermis	12	26.5%
Commiphora spp.	2	4.5%
Acacia tortilis	29	64.4%
Dodonaea spp.	4	8.9%
EUPHORBIACEAE	10	22.2%

Table 1 Anthropogenic Fauna Indicator Ubiquity

Detrended Correspondence Analysis

The DCA includes all 89 species, 37 are unidentified while 53 are identified. DCAs format data on a multidimensional space, reflecting the multiple species and site relationships. The output of a DCA is often represented as a scattergram, which captures only two dimensions of this multi-dimensional space, see Figure 4. The DCA then plots the differences between each species and how they relate to each site. The DCA only represents species which are present within 5% or more of sites to reduce noise and redundancy within the data. *Acacia spp.* and *Dodonaea spp.* are the only anthropogenically-linked species which are present within at least 5% of sites and therefore the only ones included in the DCA. Twelve sites were not 14C tested and were thus removed from the DCA analysis.

The scattergram exhibits patterns between species and sites. On the first of two axes, a pattern emerges with the older sites on the right of the DCA1 and younger sites on the left. The older sites associate with higher concentrations of woody species such as *Ziziphus spp*. and *Ficus spp.*, and with stems, which form in the habits of robust, upright, and woody forbs. DCA1 axis also shows a pattern in which species' diversity is greater in younger and modern assemblages. The DCA2 is actually a loaded factor which described the influence of multiple variables. The loaded factor accounts for more variance of species composition not accounted for with DCA1. The DCA analyzed the difference between site-species distribution. The CCA supplements this analysis but also analyzes the bacauses of variance identified within in the random distribution.

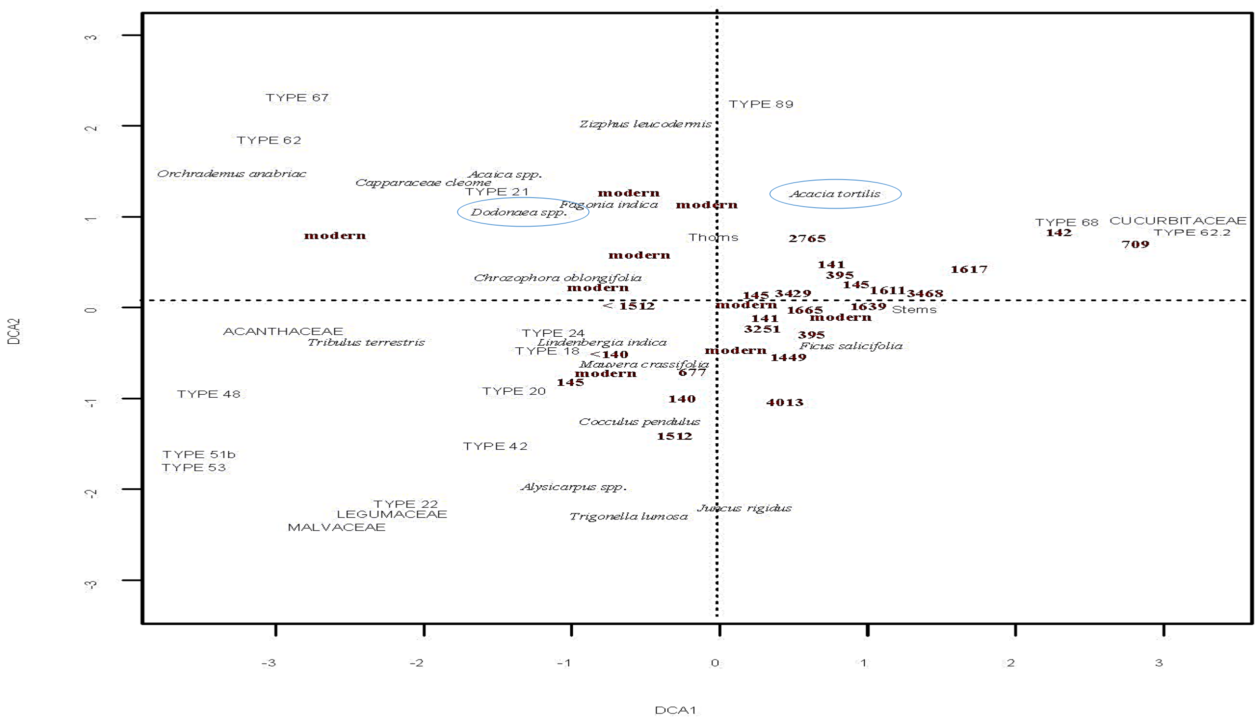

Figure 4 Scattergram of the Detrended Correspondence Analysis, Indicator Species circled

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Canonical Correspondence Analysis

Inertia Proportion Rank		
Total	3.5928	1.0000
Constrained	0.9167	0.2551
Unconstrained	2.6761	0.7449

Table 2 CCA Constraint Variance

As our study aims to identify anthropogenic plant indicators relationship with human land use in localized hyrax assemblages, we conducted a canonical correspondence analysis. The canonical correspondence analysis (CCA) is based on the weighted abundance of macrobotanical species found within each sample. The preliminary results of the DCA showed two main trends; corresponding age of midden samples to unique species, with woodier species greater in the older samples and more diverse makeup of ground covering species within modern species. This suggests that middens assemblages reflect greatly the age and location of the midden. Therefore, supporting the use of environmental variables of 14C for each midden and latitude as an explanatory variables. Explanatory variables, human monuments and freshwater springs, are known records of past human presences. Fig. 5 shows the CCA scattergram of the 45 hyrax samples and 89 selected species types in relation to 4 explanatory variables.

All these 4 environmental, explanatory variables explain 26% of the variation in the species data, whereas 74% is explained by other, unidentified covariables. Table 3 presents the constrained and unconstrained variance. The environmental variables – latitude and distance from springs freshwater springs–show a strong, positive correlation (r=0.65). Springs decrease in abundance the further into the Nejd. Middens sites, located further into the Nejd, are found on average 5,000 to 8,000 meters from a freshwater spring. Latitude and distance to monuments showed a weak, negative correlation (r=-0.37), because many human monuments are located further from the coastal plain in the Nejd.

Constraint Statistics				
Constraint	VIF Score	P – Value	X squared	F
Latitude	1.49	0.706	0.05	0.40
Distance to Freshwater Springs	1.80	0.037*	0.27	2.04
Distance to Human Monuments	1.5	0.003***	0.49	3.65
Age of Midden (BP)	1.11	0.359	0.17	1.25

Table 3 Effects of Each Constraining Variables

VIF scores, variance inflation factor, were calculated to rule out collinearity. The VIF scores reported (see table 3) for all four variables are less than 2, deeming them uncorrelated to other explanatory variables (measures of 4 – 5 are moderate collinearity). The low VIF scores show the variables used are not collinear or had low collinearity. Thus, both variables are valuable in explaining of species variance. Figure 5 is the biplot from of the canonical correspondence analysis. The CCA is based on two different components: species and the variables (biplot arrows) (Oksanen 2015). The anthropogenic indicator species meeting the 1% threshold are in red bold font and include *Ziziphus leucodermis*, *Acacia tortilis, Dodonaea spp.,* and EUPHORBIACEAE .

The environmental variables, otherwise known as vectors, intersect at the origin of the two CCA axes. The origin is the average of each unique, linear numerical data collected from each constraint. All of the four indicator taxa, which met the 1% threshold, are situated near the origin, suggesting that they have little relation to the measured local environmental variables (Braak 1986; Gaillard et al. 1994) or they may be commonly recorded in most of the sites investigated and characterized by various environmental conditions and different variations of land-use (Mazier et al. in press).

The species relate to each constraint individually and against the other species present in assemblages, projecting the species to a unique place on the biplot as affected by all other CCA components (Oksanen 2015). When one looks at the species scores projected along the first two CCA axes, it appears that the indicator species, *Ziziphus leucodermis*, and the genus EUPHORBIACEAE are found being explained slightly more due to the latitude. This is typical due to the hyper arid, growing environments needed for these genus.

The over all hyrax site-species relationship is explained by two main variables which fall are within the confidence level ($p < 0.05$): distance to human monuments (p-0.003) and distant to freshwater springs (p-0.037). These two explanatory variables are not directly impacting any one of the four indicator species, but are effecting the variance amongst all species.

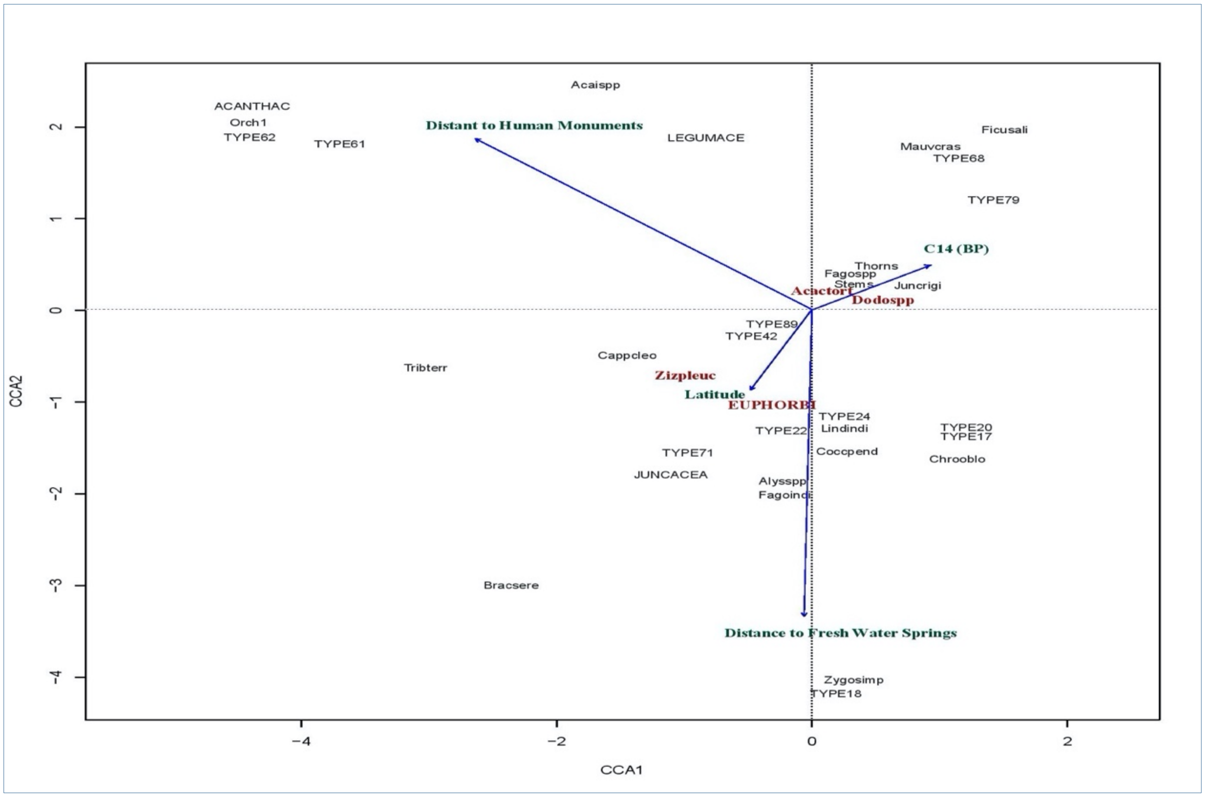

Figure 5 Biplot of the Conociol Correspondence Analysis. The four variables Distance to Freshwater Springs, Distance to Human Monuments, 14C Date, and Longitude explain 25.5% of the variance within hyrax assemblages. All 45 samples are represented. Distance to human monuments and Distance to freshwater

Interpretation

This study aimed to understand hyrax middens' capabilities to yield identifiable fossilized macrobotanicals as paleo-proxies for ancient plant communities at different points in time and space. Ethnobotanical and statistical interpretation of the ancient plant communities plant within the hyrax sites assists in understanding human's presence in the past environment. Two main conclusion were drawn from the ubiquity, DCA, and CCA analyses of site-species relationship. The results are not able to be extrapolated to the whole region of Dhofar since sites were only sampled in a few of Dhofar's wadis.

Hypothesis 1 - Hyrax Middens Produce Paleo-vegetation Proxies

The analysis of hyrax middens' macrobotanical remains allows for the environmental reconstructions of localized vegetation communities in the Nejd. The DCA scattergraph plotted a greater abundance of woody species present around grouping of sites from the 1400 years BP. The relationship of species shift throughout time suggests site based, hyrax middens are a viable paleo-proxy records for vegetation reconstruction.

Taphonomy and preservation likely affected the range and presences of species distributions. To control for poor preservation, we looked at species distribution and ligneous tissue. Ligneous tissues found within stems allow for easier preservation (Barrows et. al 2015). *Cocculus pendulus* on the CCA biplot (Figure 5) is known for high levels of ligneous tissues, found in the hard and thick pericarp (Baldorf 1871). Therefore, we should expect *C.pendulus* if present in the past environment to preserve, thus being plotted nearer to the older sites.

Hypothesis 2 - Human – Environmental Variables

The second hypothesis examines hyrax middens capture plant indicators of human activity within Dhofar over the past 3500 yrs. BP. Humans' presence in the environment, for which monument location is a proxy, shows specific chronological gaps between 4500 BCE to 3000 BCE and 1800 BCE to 1000BCE (McCorriston et. al. 2008). Hyrax midden site WP155-F is our oldest dated midden site dating to around 2000 BCE The temporal trend shown in the DCA exhibits woody species are strongly associated with the oldest middens, suggesting denser forest coverage during human occupation. Paleo-stem data suggests the regional aridification affected Dhofar beginning when humans were not present in the Nejd, 4.5kya (Fleitmann et al 2007). As the aridification ceased, the woody species are present in the plant record as are humans in the monument record. This connection between species, climate, and human relationships is extremely intriguing and warrants investigation into the unique variables included in each.

The site-species relationship produced in the DCA is constrained more by unique variables of distance of hyrax sites to both human monuments and freshwater in the CCA. The strong relationship between site assemblages and human explanatory variables, provide fascinating insight unto human monument-hyrax vegetation relationships for it shows human presence influences the species distribution.

The indicator species approach allowed for plants to be identified which are implicitly driven by human interaction. The ability of hyrax midden sites vegetation collection to indicate human presence through these anthropogenic flora indicators are limited. *Commiphora spp* does not appear as a significant species in any of the sites. The CCA explained the 26% patterns of vegetation revealed within the DCA, leaving many variables unaccounted.

Discussion

For future analysis of anthropogenic indicators, a combination of pollen data with macrobotanical remains can offer researchers higher taxonomic resolutions on the species present. EUPORIBACEAE has the potential ability to reconstruct vegetation community strongly affected by climatic and humans variables. Due to the many species included within this family, many ethnobotanical plants are found within the EUPORBIACEAE family. Further research into *Euphorbia balsaminifera,* within assemblages can illuminate ethnobotanical relationships. *Euphorbia balsaminifera* is a descriptive plant in defining a plant community at the interface of plateau and Nejd (Miller and Morris 1988)

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Appendix

A. Weight Abundance of Species within Site

ID	57-4 Top	57-4 Bottom	79-2c	38-2 Top	61-2	67-4	38-2 Bottom
CUCURBITACEAE	0	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0	0
SALVADORACEAE	0	0	0	0	0	0	0
SOLANCEAE	0	0	0	0	0	0	0
BRASSICACEAE	0	0	0.766283525	0	0	0	0
Cymbopogon spp.	0	0	0	0	0	0	0
Zizphus leucodermis	0	0	40.61302682	0	46.92082111	44.22745549	0
Commiphora myrrha	0	0	0	0	0	0	0
Commiphora spp.	0	0	0	0	0	0	0
Acacia tortilis	0	0	0	0	0	0	0
Acacia spp.	0	0.571428571	31.80076628	0	2.346041056	0	0
Carex limosa	0	0	0	0	0	0	0
Ochradenus spp.	0	0	0	0	0	0	0
Cocculus pendulus	13.15789474	61.71428571	0	7.692307692	10.55718475	32.16542217	24.78632479
Alysicarpus spp.	2.631578947	1.714285714	0	0	0	0	5.128205128
Trigonella lumosa	0	0	0	0	0	0	5.128205128
Amaranthus spp.	0	0	0	0	0	0	0
Lindenbergia indica	5.263157895	0	1.53256705	0.961538462	0	0.574382539	0.854700855
Carex spp.	0	0	0	0	0	0	0
Atractylis spp.	0	0	0	0.961538462	0	0	0.854700855
Reseda sphenoides	0	0.571428571	0	0.961538462	0	0	0
Dodonaea spp.	0	0	0	0	0	0	0
Polygonum spp.	0	0	0	0	0	0	0
Chrozophora oblongifolia	39.47368421	0	0	0	3.225806452	7.466973004	0
Brachiaria spp.	0	0	0	0	0	0	0
BORAGINACEAE	0	0	0	0	0	0.574382539	0
MALVACEAE	0	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0	0
Fagonia indica	0	0	0	0.961538462	2.052785924	0	0.854700855
Fagonia spp.	0	0	0	0	0	0	0
Fagonia ovalifolia	0	0	0	0	0	0	0
Fagonia arabica	0	0	0	0	0	0	0
Achyranthes aspera	0	0	0	0	0	0	0
JUNCACEAE	0	0	0	0	0	0	0
Juncus rigidus	0	0	0	0	0	0	0
Pupalia lappacea	0	0	0	0	0	0	0
ACANTHACEAE	0	0	0	0	0	0	0
Ziziphus spp.	0	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0	0
Euphorbia granulata	0	0	0	0	0	0	0
EUPHORBIACEAE	0	0.571428571	0.766283525	0.961538462	1.173020528	0.631820793	0
Cenchrus ciliaris	0	0	0	0	0	0	0
BURSERACEAE	0	0	0	0	0	0	0
Ficus salicifolia	0	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0	0

ID	57-4 Top	57-4 Bottom	79-2c	38-2 Top	61-2	67-4	38-2 Bottom
Maerua crassifolia	0	0	1.149425287	0	0	0	0
Thorns	0	2.285714286	0	1.923076923	1.46627566	4.59506031	0
Tribulus terrestris	2.631578947	0	0	1.923076923	0.293255132	0	0
Stems	28.94736842	29.71428571	22.60536398	79.80769231	31.37829912	9.19012062	59.82905983
Zygophyllum simplex	0	0.571428571	0	0	0	0	0
CAPPARACEAE	0	0	0	0.961538462	0.293255132	0.574382539	0
TYPE 45	0	0	0	0	0	0	0
TYPE 48	0	0	0	0	0	0	0
51b.UNKNOWN	0	0	0	0	0	0	0
TYPE 53	0	0	0	0	0	0	0
TYPE 39	0	0	0	0	0	0	0
TYPE 42	0	0	0	0	0	0	0
TYPE 67	0	0	0	0	0	0	0
TYPE 37	0	0	0	0	0	0	0
TYPE 12	0	0	0	0	0	0	0.854700855
TYPE 9	0	0	0	0	0	0	1.709401709
TYPE 17	0	1.142857143	0	0	0	0	0
TYPE 18	0	0.571428571	0	0	0	0	0
TYPE 19	0	0	0	0	0	0	0
TYPE 20	0	0.571428571	0	0	0	0	0
TYPE 21	0	0	0	0	0	0	0
TYPE 22	2.631578947	0	0.383141762	0	0	0	0
TYPE 23	0	0	0.383141762	0	0	0	0
TYPE 24	5.263157895	0	0	2.884615385	0.293255132	0	0
TYPE 60	0	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0	0
TYPE 68-2	0	0	0	0	0	0	0
TYPE 68	0	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0	0
TYPE 62-2	0	0	0	0	0	0	0
TYPE 62	0	0	0	0	0	0	0
TYPE 58	0	0	0	0	0	0	0
TYPE 70	0	0	0	0	0	0	0
TYPE 71	0	0	0	0	0	0	0
TYPE 72	0	0	0	0	0	0	0
TYPE 73	0	0	0	0	0	0	0
TYPE 64	0	0	0	0	0	0	0
TYPE 76	0	0	0	0	0	0	0
TYPE 78	0	0	0	0	0	0	0
TYPE 79	0	0	0	0	0	0	0
TYPE 81	0	0	0	0	0	0	0
TYPE 89	0	0	0	0	0	0	0
TYPE 88	0	0	0	0	0	0	0
ROSACEAE	0	0	0	0	0	0	0

ID	61-1	48-1 Bottom	67-3	79-1a	19	18	83-1
CUCURBITACEAE	0	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0	0
SALVADORACEAE	0	0	0	0	0	0	0
SOLANCEAE	0	0	0	0	0	0	0
BRASSICACEAE	0	0	0	0	0	0	0
Cymbopogon spp.	0	0	0	0	0	0	0
Zizphus leucodermis	0	13.33333333	2.784048157	7.860262009	0	0	0
Commiphora myrrha	0	0	0	0	0	0	0
Commiphora spp.	0	0	0	0	0	0.754906895	0
Acacia tortilis	0	0	0	0	0	0	0
Acacia spp.	0	0	0	3.930131004	0.29535865	0	3.912363067
Carex limosa	0	0	0	0	0	0	0
Ochradenus spp.	0	0	0	0	0	0	0
Cocculus pendulus	52.17391304	0	59.06696764	3.493449782	0.168776371	0	0
Alysicarpus spp.	0	0	0	0	0	0	0
Trigonella lumosa	0	0	0.075244545	0	0	0	0
Amaranthus spp.	0	0	0	0	0	0	0
Lindenbergia indica	4.347826087	6.666666667	0.677200903	0.873362445	0.210970464	0.050327126	0
Carex spp.	0	0	0	0	0	0	0
Atractylis spp.	0	0	0	0	0	0	0
Reseda sphenoides	0	0	0.075244545	0	0.042194093	0.050327126	0
Dodonaea spp.	0	0	0	0	0	3.673880221	0
Polygonum spp.	0	0	0	0	0	0	0
Chrozophora oblongifolia	0	0	0	0	0	0	0
Brachiaria spp.	0	0	0	0.436681223	0	0	0
BORAGINACEAE	0	0	0.15048909	0	0	0.855561147	0
MALVACEAE	0	0	0	0	0.337552743	0	0
FABACEAE	0	0	0	0	0	0	2.034428795
Fagonia indica	0	6.666666667	0.978179082	0.436681223	0	0	0
Fagonia spp.	0	0	0	0	0	0	0
Fagonia ovalifolia	0	0	0	0	0	0	0
Fagonia arabica	0	0	0	0	1.054852321	0	0
Achyranthes aspera	0	0	0	0.436681223	0.717299578	0	0
JUNCACEAE	0	0	0	0	0	0	0
Juncus rigidus	0	0	0	0	0.548523207	0	0
Pupalia lappacea	0	0	0	0	0.29535865	0	0
ACANTHACEAE	0	0	0	0	0.168776371	5.88827378	11.42410016
Ziziphus spp.	0	0	0	0	0.042194093	0	0
Ochradenus arabicus	0	0	0	0	0.042194093	0	0
Euphorbia granulata	0	0	0	0	0	0	0
EUPHORBIACEAE	0	0	0	0	0	0	0
Cenchrus ciliaris	0	0	0	0	0	0	0
BURSERACEAE	0	0	0	0	0	0	0
Ficus salicifolia	0	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	7.851031706	22.53521127

ID	61-1	48-1 Bottom	67-3	79-1a	19	18	83-1
Maerua crassifolia	0	6.666666667	0.300978179	0.873362445	0	36.73880221	3.912363067
Thorns	0	13.33333333	0.601956358	1.746724891	0.5907173	2.667337695	0.938967136
Tribulus terrestris	4.347826087	0	29.49586155	0	0	12.4308002	44.60093897
Stems	30.43478261	0	0.376222724	0	9.367088608	0	0
Zygophyllum simplex	4.347826087	0	0	0	0	0	0
CAPPARACEAE	0	6.666666667	0	0.436681223	0	10.46804227	0.469483568
TYPE 45	0	0	0	0	0.210970464	0	0
TYPE 48	0	0	0	0	21.94092827	12.07851032	0
51b.UNKNOWN	0	0	0	0	41.89873418	0	0
TYPE 53	0	0	0	0	16.4978903	0	0
TYPE 39	0	0	0	0	0	0	0
TYPE 42	0	0	4.815650865	0	3.88185654	1.761449421	0
TYPE 67	0	0	0	76.41921397	0	0	0
TYPE 37	0	0	0	0	0	0	0
TYPE 12	0	0	0	0.873362445	0	0	0
TYPE 9	0	0	0	0	0	0	0
TYPE 17	0	0	0	0	0	0	0
TYPE 18	4.347826087	6.666666667	0	0	0	0.704579768	0
TYPE 19	0	0	0	0	0	0	0
TYPE 20	0	6.666666667	0	0	0	0	0
TYPE 21	0	6.666666667	0	0	0.042194093	0	0
TYPE 22	0	0	0	0	0	0	0
TYPE 23	0	0	0	0	0	0	0
TYPE 24	0	26.66666667	0.075244545	0	1.561181435	3.673880221	0
TYPE 60	0	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0	4.851330203
TYPE 68-2	0	0	0	0	0	0	0
TYPE 68	0	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0	0
TYPE 62-2	0	0	0	0	0	0	0
TYPE 62	0	0	0	2.183406114	0	0	5.320813772
TYPE 58	0	0	0.526711813	0	0.084388186	0.352289884	0
TYPE 70	0	0	0	0	0	0	0
TYPE 71	0	0	0	0	0	0	0
TYPE 72	0	0	0	0	0	0	0
TYPE 73	0	0	0	0	0	0	0
TYPE 64	0	0	0	0	0	0	0
TYPE 76	0	0	0	0	0	0	0
TYPE 78	0	0	0	0	0	0	0
TYPE 79	0	0	0	0	0	0	0
TYPE 81	0	0	0	0	0	0	0
TYPE 89	0	0	0	0	0	0	0
TYPE 88	0	0	0	0	0	0	0
ROSACEAE	0	0	0	0	0	0	0

ID	57-2	61-3	2--1	45-2	103-2c	108-1B
CUCURBITACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0.203873598	0
SALVADORACEAE	0	0	0	0	0.101936799	0
SOLANCEAE	0	0	0	0	0.101936799	0
BRASSICACEAE	0	0	0	0.295857988	0	0
Cymbopogon spp.	0	0	0	0	0.101936799	0
Zizphus leucodermis	0.277777778	0.174825175	0.106496273	0	19.06218145	0
Commiphora myrrha	0	0	0	0	0	0
Commiphora spp.	0	0	0	0	0	0
Acacia tortilis	0	0	0	0	0.611620795	2.208835341
Acacia spp.	8.333333333	0	13.31203408	2.958579882	0.203873598	1.004016064
Carex limosa	0	0	0	0	0	0.200803213
Ochradenus spp.	0	0	0	0	0	0
Cocculus pendulus	12.77777778	0.174825175	7.561235357	39.9408284	0.101936799	0
Alysicarpus spp.	0	0	0	2.366863905	0	0
Trigonella lumosa	0	0	0	0	0	0
Amaranthus spp.	0	0	0	0	0	0
Lindenbergia indica	1.944444444	0.874125874	0.425985091	1.775147929	0.101936799	0.200803213
Carex spp.	0	0	0	0	0	0
Atractylis spp.	0	0	0	0	0	0
Reseda sphenoides	0.277777778	0.174825175	0	0.295857988	0	0
Dodonaea spp.	0	0.874125874	0	0	0	0
Polygonum spp.	0	0	0	0	0	0
Chrozophora oblongifolia	0	0	0	0	0	0
Brachiaria spp.	0	0	0	2.958579882	0	0
BORAGINACEAE	0.277777778	0	0	0	0	0
MALVACEAE	8.333333333	0	0	0	0	0
FABACEAE	33.33333333	0	0	0	0	3.614457831
Fagonia indica	0	0.174825175	0	0.887573964	0	0
Fagonia spp.	0	0	0	0	0.101936799	0.401606426
Fagonia ovalifolia	0	0	0	0	0	0
Fagonia arabica	0	0	0	0	0	0
Achyranthes aspera	0	0.174825175	0	0	0	0
JUNCACEAE	0	0	0	0	4.689092762	0
Juncus rigidus	0	0	0	0	0	0
Pupalia lappacea	0	0	0	0	0	0
ACANTHACEAE	0	0	15.12247071	0	0	0
Ziziphus spp.	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0
Euphorbia granulata	0	0	0	0	0	0
EUPHORBIACEAE	0	0	0	0	0.101936799	0
Cenchrus ciliaris	0	0	0.106496273	0	0	0
BURSERACEAE	0	0	0	0	0	0
Ficus salicifolia	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0

ID	57-2	61-3	2--1	45-2	103-2c	108-1B
Maerua crassifolia	0.555555556	4.895104895	0.532481363	0	0.101936799	12.65060241
Thorns	1.388888889	1.223776224	0.532481363	0	1.427115189	4.819277108
Tribulus terrestris	18.33333333	88.11188811	61.98083067	43.49112426	0	0
Stems	0	1.048951049	0	0.295857988	70.13251784	72.28915663
Zygophyllum simplex	0.277777778	0	0	0	0	0
CAPPARACEAE	0.277777778	0	0.106496273	0.295857988	0	0
TYPE 45	0	0	0	0	0	0
TYPE 48	0	0	0	0	0	0
51b.UNKNOWN	0	0	0	0	0	0
TYPE 53	0	0	0	0	0	0
TYPE 39	0.277777778	0	0	0	0	0
TYPE 42	0	0	0	0	0	0
TYPE 67	0	0	0	0	0	0
TYPE 37	0	0.34965035	0	0	0	0
TYPE 12	0	0	0	0	0	0
TYPE 9	0	0	0	0	0	0
TYPE 17	0	0	0	0	0	0
TYPE 18	0	0.174825175	0	0.295857988	0	0
TYPE 19	0	0	0	0	0	0
TYPE 20	0.555555556	0	0	0	0	0
TYPE 21	0	0	0	0	0	0
TYPE 22	12.22222222	0	0	1.183431953	0	0
TYPE 23	0	0	0	0	0	0
TYPE 24	0.555555556	0.874125874	0.106496273	2.958579882	0	0.401606426
TYPE 60	0	0.699300699	0	0	0	0
TYPE 61	0	0	0	0	0	0
TYPE 68-2	0	0	0	0	0	0
TYPE 68	0	0	0	0	0	1.204819277
TYPE 61	0	0	0	0	0	0
TYPE 62-2	0	0	0	0	0	0
TYPE 62	0	0	0	0	0	0
TYPE 58	0	0	0.106496273	0	0	0.200803213
TYPE 70	0	0	0	0	0.101936799	0.200803213
TYPE 71	0	0	0	0	2.752293578	0.200803213
TYPE 72	0	0	0	0	0	0.200803213
TYPE 73	0	0	0	0	0	0.200803213
TYPE 64	0	0	0	0	0	0
TYPE 76	0	0	0	0	0	0
TYPE 78	0	0	0	0	0	0
TYPE 79	0	0	0	0	0	0
TYPE 81	0	0	0	0	0	0
TYPE 89	0	0	0	0	0	0
TYPE 88	0	0	0	0	0	0
ROSACEAE	0	0	0	0	0	0

ID	107-2B	146	133-1A	144-6	143	155-F
CUCURBITACEAE	0	37.81512605	0	0	0	0
FABACEAE	0	0	0	0	0	0
SALVADORACEAE	0	0	0	0	0	0
SOLANCEAE	0	0	0	0	0	0
BRASSICACEAE	0	0	0	0	0	0
Cymbopogon spp.	0	0	0	0	0	0
Zizphus leucodermis	0	0	0	0	0	0
Commiphora myrrha	0	0.420168067	0	0	0	0
Commiphora spp.	0	0	0	0	0	0
Acacia tortilis	0.356472795	0	0	0	0	0
Acacia spp.	0.168855535	0.420168067	0	0.877192982	0	2.02020202
Carex limosa	0	0	0	0	0	0
Ochradenus spp.	0.018761726	0	0	0	0	0
Cocculus pendulus	0.018761726	0.420168067	0	0	4.276315789	8.484848485
Alysicarpus spp.	0	0	0	0	0	0
Trigonella lumosa	0	0	0	0	0	0
Amaranthus spp.	0	0	0	0	0	0
Lindenbergia indica	0.018761726	0	0.316455696	1.754385965	0.986842105	0.202020202
Carex spp.	0	0	0	0	0	0.202020202
Atractylis spp.	0	0	0	0	0	0
Reseda sphenoides	0	0	0	0	0	0
Dodonaea spp.	0	0	0	0	0	0
Polygonum spp.	0	0	0	0	0	0
Chrozophora oblongifolia	0	0	0	0	0	0
Brachiaria spp.	0	0	0	0	0	0
BORAGINACEAE	0	0	0	0	0	0
MALVACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0
Fagonia indica	0	0	0.632911392	0.877192982	0	0.202020202
Fagonia spp.	0	0	0	0	1.973684211	0.202020202
Fagonia ovalifolia	0	0	0	0.877192982	0	0
Fagonia arabica	0	0	0	0	0	0
Achyranthes aspera	0	0	0	0	0	0
JUNCACEAE	0	0	0	0	0	0
Juncus rigidus	0	0	0	0	0	15.15151515
Pupalia lappacea	0	0	0	0	0	0
ACANTHACEAE	0	0	0	0	0	0
Ziziphus spp.	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0
Euphorbia granulata	0	0	0	0.877192982	0	0
EUPHORBIACEAE	0	0	0	0	0	0
Cenchrus ciliaris	0	0	0	0	0	0
BURSERACEAE	0	0	0	0	0	0
Ficus salicifolia	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0

ID	107-2B	146	133-1A	144-6	143	155-F
Maerua crassifolia	0	0	26.58227848	0.877192982	0.328947368	0.202020202
Thorns	0.187617261	0	2.215189873	1.754385965	2.631578947	2.02020202
Tribulus terrestris	0	0	0	0	0	0
Stems	2.889305816	51.68067227	68.35443038	90.35087719	89.14473684	69.6969697
Zygophyllum simplex	0	0	0	0	0	0
CAPPARACEAE	0	0	0	0	0	0
TYPE 45	0	0	0	0	0	0
TYPE 48	0	0	0	0	0	0
51b.UNKNOWN	0	0	0	0	0	0
TYPE 53	0	0	0	0	0	0
TYPE 39	0	0	0	0	0	0
TYPE 42	0	0	0	0	0	0
TYPE 67	0	0	0	0	0	0
TYPE 37	0	0	0	0	0	0
TYPE 12	0	0	0	0	0	0
TYPE 9	0	0	0	0	0	0
TYPE 17	0	0	0	0	0	0
TYPE 18	0	0	0	0	0	0
TYPE 19	0	0	0	0	0	0
TYPE 20	0	0	0	0	0	0
TYPE 21	0	0	0	0	0	0
TYPE 22	0	0	0	0	0	0
TYPE 23	0	0	0	0	0	0
TYPE 24	0.037523452	0	0.316455696	1.754385965	0.328947368	0.404040404
TYPE 60	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0.808080808
TYPE 68-2	0	0	0.316455696	0	0	0
TYPE 68	95.34709193	3.361344538	0.949367089	0	0	0.404040404
TYPE 61	0	0	0.316455696	0	0	0
TYPE 62-2	0	5.882352941	0	0	0	0
TYPE 62	0	0	0	0	0	0
TYPE 58	0	0	0	0	0	0
TYPE 70	0	0	0	0	0	0
TYPE 71	0	0	0	0	0	0
TYPE 72	0.506566604	0	0	0	0	0
TYPE 73	0	0	0	0	0	0
TYPE 64	0.450281426	0	0	0	0	0
TYPE 76	0	0	0	0	0.328947368	0
TYPE 78	0	0	0	0	0	0
TYPE 79	0	0	0	0	0	0
TYPE 81	0	0	0	0	0	0
TYPE 89	0	0	0	0	0	0
TYPE 88	0	0	0	0	0	0
ROSACEAE	0	0	0	0	0	0

ID	155-D	153-2	149-2	142-B	145-4	135-3
CUCURBITACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0
SALVADORACEAE	0	0	0	0	0	0
SOLANCEAE	0	0	0	0	0	0
BRASSICACEAE	0	0	0	0	0	0
Cymbopogon spp.	0	0	0	0	0	0
Zizphus leucodermis	0	0	0	0	0	51.36986301
Commiphora myrrha	0	0	0	0	0	0
Commiphora spp.	0	0	0	0	0	0
Acacia tortilis	0	0	0	0.491400491	0	0
Acacia spp.	0.398406375	0.251889169	0.366300366	0	0	0
Carex limosa	0	0	0	0	0	0
Ochradenus spp.	0	0	0	0	0	0
Cocculus pendulus	5.77689243	21.66246851	14.28571429	0	0	0.547945205
Alysicarpus spp.	0	0	0	0	0	0
Trigonella lumosa	0	0	0	0	0	0
Amaranthus spp.	0	0	0	0	0	0
Lindenbergia indica	0.199203187	0	0.366300366	0	0	0.136986301
Carex spp.	0	0	0	0	0	0
Atractylis spp.	0	0	0	0	0	0
Reseda sphenoides	0	0	0	0	0	0
Dodonaea spp.	1.394422311	0	0	0	0	0
Polygonum spp.	0	0	0	0	0	0
Chrozophora oblongifolia	0	0	0	0	0	0
Brachiaria spp.	0	0	0	0	0	0
BORAGINACEAE	0	0	0	0	0	0
MALVACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0
Fagonia indica	0	0.251889169	0.366300366	0	0	0
Fagonia spp.	0.597609562	0	0	0.737100737	0.888888889	0.684931507
Fagonia ovalifolia	0	0	0	0	0	0
Fagonia arabica	0	0	0	0	0	0
Achyranthes aspera	0	0	0	0	0	0
JUNCACEAE	0	0	0	0	0	0
Juncus rigidus	0	0	0	0	0	0
Pupalia lappacea	0	0	0	0	0	0
ACANTHACEAE	0	0	0	0	0	0
Ziziphus spp.	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0
Euphorbia granulata	0	0	0	0	0	0
EUPHORBIACEAE	0.199203187	0	0	0	0	0
Cenchrus ciliaris	0	0	0	0	0	0
BURSERACEAE	0	0.503778338	0	0	0	0
Ficus salicifolia	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0

ID	155-D	153-2	149-2	142-B	145-4	135-3
Maerua crassifolia	0.398406375	0	13.91941392	0	0	0
Thorns	2.390438247	0.251889169	0.732600733	4.422604423	0.444444444	0.273972603
Tribulus terrestris	0	0	1.465201465	0	0	0
Stems	88.24701195	76.07052897	65.56776557	94.1031941	98.66666667	34.10958904
Zygophyllum simplex	0	0.251889169	0	0	0	0
CAPPARACEAE	0	0	0.366300366	0	0	0
TYPE 45	0	0	0	0	0	0
TYPE 48	0	0	0	0	0	0
51b.UNKNOWN	0	0	0	0	0	0
TYPE 53	0	0	0	0	0	0
TYPE 39	0	0	0	0	0	0
TYPE 42	0	0.251889169	0	0	0	0
TYPE 67	0	0	0	0	0	0
TYPE 37	0	0	0	0	0	0
TYPE 12	0	0	0	0	0	0
TYPE 9	0	0	0	0	0	0
TYPE 17	0	0	0	0	0	0
TYPE 18	0	0	0	0	0	0
TYPE 19	0	0	0	0	0	0
TYPE 20	0	0	0	0	0	0
TYPE 21	0	0	0	0	0	0
TYPE 22	0	0	0	0	0	0
TYPE 23	0	0	0	0	0	0
TYPE 24	0.199203187	0	0.366300366	0.122850123	0	0
TYPE 60	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0
TYPE 68-2	0	0	0	0	0	0.273972603
TYPE 68	0.199203187	0.503778338	0.366300366	0	0	0
TYPE 61	0	0	0	0	0	0
TYPE 62-2	0	0	0	0	0	0
TYPE 62	0	0	0	0	0	0
TYPE 58	0	0	0	0	0	0
TYPE 70	0	0	0	0	0	0
TYPE 71	0	0	0	0	0	0
TYPE 72	0	0	0	0	0	0
TYPE 73	0	0	0	0	0	0
TYPE 64	0	0	0	0	0	0
TYPE 76	0	0	0	0	0	0
TYPE 78	0	0	0.366300366	0	0	0
TYPE 79	0	0	1.465201465	0	0	0
TYPE 81	0	0	0	0.122850123	0	0.273972603
TYPE 89	0	0	0	0	0	12.32876712
TYPE 88	0	0	0	0	0	0
ROSACEAE	0	0	0	0	0	0

ID	107-1	135-2	155-2C	140	144-4	147-1
CUCURBITACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0
SALVADORACEAE	0	0	0	0	0	0
SOLANCEAE	0	0	0	0	0	0
BRASSICACEAE	0	0	0	0	0	0
Cymbopogon spp.	0	0	0	0	0	0
Zizphus leucodermis	0	51.5625	0	0	0	0
Commiphora myrrha	0	0	0	0	0	0
Commiphora spp.	0	0	0	0	0	0
Acacia tortilis	0	0	0	0	7.195571956	3.125
Acacia spp.	0	0	0	0	0	0
Carex limosa	0	0	0	0	0	0
Ochradenus spp.	0	0	0	0	0	0
Cocculus pendulus	0	1.682692308	34.56790123	0	21.95571956	0.3125
Alysicarpus spp.	0	0	0	0	0	0
Trigonella lumosa	0	0	0	0	0	0
Amaranthus spp.	0	0	0	0	0	0
Lindenbergia indica	0.326797386	0.120192308	0.411522634	0	0.36900369	0.3125
Carex spp.	0	0	0	0	0	0
Atractylis spp.	0	0	0	0	0	0
Reseda sphenoides	0	0	0	0	0	0
Dodonaea spp.	0	0	0	0	0	0
Polygonum spp.	0	0	0	0	0	0
Chrozophora oblongifolia	0	0	0	0	0	0
Brachiaria spp.	0	0	0	0	0	0
BORAGINACEAE	0	0	0	0	0	0
MALVACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0
Fagonia indica	0	0	0	0	0	0
Fagonia spp.	0.980392157	0.240384615	0.411522634	2.955665025	0.184501845	0.625
Fagonia ovalifolia	0	0	0	0	0	0
Fagonia arabica	0.326797386	0	0	0	0	0
Achyranthes aspera	0	0	0	0	0	0
JUNCACEAE	0	0	0	0	0	0
Juncus rigidus	0	0	0	0	0	0
Pupalia lappacea	0	0	0	0	0	0
ACANTHACEAE	0	0	0	0	0	0
Ziziphus spp.	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0
Euphorbia granulata	0	0	0	0	0	0
EUPHORBIACEAE	0.326797386	0.120192308	0.411522634	0	0	0
Cenchrus ciliaris	0	0	0	0	0	0
BURSERACEAE	0	0	0	0	0	0
Ficus salicifolia	5.22875817	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0

ID	107-1	135-2	155-2C	140	144-4	147-1
Maerua crassifolia	3.594771242	0.120192308	0.411522634	0.492610837	0.184501845	7.8125
Thorns	5.22875817	0.240384615	0.823045267	0.492610837	1.47601476	0.9375
Tribulus terrestris	0.326797386	0	0	0	0	0
Stems	72.22222222	38.34134615	62.55144033	95.56650246	68.26568266	85.625
Zygophyllum simplex	0	0	0	0	0	0
CAPPARACEAE	0	0	0	0	0	0
TYPE 45	0	0	0	0	0	0
TYPE 48	0	0	0	0	0	0
51b.UNKNOWN	0	0	0	0	0	0
TYPE 53	0	0	0	0	0	0
TYPE 39	0	0	0	0	0	0
TYPE 42	0	0	0	0	0	0
TYPE 67	0	0	0	0	0	0
TYPE 37	0	0	0	0	0	0
TYPE 12	0	0	0	0	0	0
TYPE 9	0	0	0	0	0	0
TYPE 17	0	0	0	0	0	0
TYPE 18	0	0	0	0	0	0
TYPE 19	0	0	0	0	0	0
TYPE 20	0	0	0	0	0	0
TYPE 21	0	0	0	0	0	0
TYPE 22	0	0	0	0	0	0
TYPE 23	0	0	0	0	0	0
TYPE 24	0	0	0	0	0	0.3125
TYPE 60	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0
TYPE 68-2	0	0	0	0	0	0
TYPE 68	11.4379085	0	0	0	0	0.9375
TYPE 61	0	0	0	0	0	0
TYPE 62-2	0	0	0	0	0	0
TYPE 62	0	0	0	0	0	0
TYPE 58	0	0	0	0	0	0
TYPE 70	0	0	0	0	0	0
TYPE 71	0	0	0	0	0	0
TYPE 72	0	0	0	0	0	0
TYPE 73	0	0	0	0	0	0
TYPE 64	0	0	0	0	0	0
TYPE 76	0	0	0.411522634	0	0	0
TYPE 78	0	0	0	0	0	0
TYPE 79	0	0	0	0.492610837	0	0
TYPE 81	0	0	0	0	0	0
TYPE 89	0	7.572115385	0	0	0.184501845	0
TYPE 88	0	0	0	0	0.184501845	0
ROSACEAE	0	0	0	0	0	0

ID	111-2E	151	155-2B	136-1	138	152-1
CUCURBITACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0
SALVADORACEAE	0	0	0	0	0	0
SOLANCEAE	0	0	0	0	0	0
BRASSICACEAE	0	0	0	0	0	0
Cymbopogon spp.	0	0	0	0	0	0
Zizphus leucodermis	0	0	0	0	0	0
Commiphora myrrha	0	0	0	0	0	0
Commiphora spp.	0	0	0	0	0	0
Acacia tortilis	0	0	0	3.503649635	0	0
Acacia spp.	3.355704698	0	0.411522634	0	0.772200772	3.278688525
Carex limosa	0	0	0	0	0	0
Ochradenus spp.	0	0	0.411522634	0.145985401	0	0
Cocculus pendulus	6.711409396	0	2.057613169	4.087591241	3.088803089	16.80327869
Alysicarpus spp.	0	0	0	0	0	0
Trigonella lumosa	0	0	0	0	0	0
Amaranthus spp.	0	0	0	0	0	0
Lindenbergia indica	0.67114094	0.392156863	0.823045267	0.291970803	0	0.614754098
Carex spp.	0	0	0	0	0	0
Atractylis spp.	0	0	0	0	0	0
Reseda sphenoides	0	0	0	0	0.386100386	0
Dodonaea spp.	0	0	0	0	0	0
Polygonum spp.	0	0	0	0	0	0
Chrozophora oblongifolia	0	0	0	0	0	0
Brachiaria spp.	0	0	0	0	0	0
BORAGINACEAE	0	0	0	0	0	0
MALVACEAE	0	0	0	0	0	0
FABACEAE	0	0	0	0	0	0
Fagonia indica	0	0	0	0	0	0
Fagonia spp.	0.67114094	1.176470588	1.234567901	0.145985401	0.386100386	1.639344262
Fagonia ovalifolia	0	0	0	0	0	0
Fagonia arabica	0	0	0	0	0	0
Achyranthes aspera	0	0	0	0	0	0
JUNCACEAE	0	0	0	0	0	0
Juncus rigidus	0	0	0	0	0	0
Pupalia lappacea	0	0	0	0	0	0
ACANTHACEAE	0	0	0	0	0	0
Ziziphus spp.	0	0	0	0	0	0
Ochradenus arabicus	0	0	0	0	0	0
Euphorbia granulata	0	0	0	0	0	0
EUPHORBIACEAE	0	0	0	0	0	0
Cenchrus ciliaris	0	0	0	0	0	0
BURSERACEAE	0	0	0	0	0	0
Ficus salicifolia	1.342281879	0	0	0	0.386100386	0
Ochradenus arabicus	0	0	0	0	0	0

ID	111-2E	151	155-2B	136-1	138	152-1
Maerua crassifolia	10.06711409	1.568627451	0	0.291970803	0.386100386	0.614754098
Thorns	4.697986577	0	2.880658436	0.583941606	0.772200772	0.614754098
Tribulus terrestris	0	0	0	0	0	0
Stems	70.46979866	42.35294118	81.48148148	83.06569343	79.15057915	71.72131148
Zygophyllum simplex	0	0	0	0	0	0
CAPPARACEAE	0	0	0	0	0	0
TYPE 45	0	0	0	0	0	0
TYPE 48	0	0	0	0	0	0
51b.UNKNOWN	0	0	0	0	0	0
TYPE 53	0	0	0	0	0	0
TYPE 39	0	0	0	0	0	0
TYPE 42	0	0	9.053497942	0	0	4.303278689
TYPE 67	0	0	0	0	0	0
TYPE 37	0	0	0	0	0	0
TYPE 12	0	0	0	0	0	0
TYPE 9	0	0	0	0	0	0
TYPE 17	0	0	0	0	0	0
TYPE 18	0	0	0	0	0	0
TYPE 19	0	0	0	0	0	0
TYPE 20	0	0	0	0	0	0
TYPE 21	0	0	0	0	0	0
TYPE 22	0	0	0	0	0	0
TYPE 23	0	0	0	0	0	0
TYPE 24	0	0	0.411522634	0	0	0.204918033
TYPE 60	0	0	0	0	0	0
TYPE 61	0	0	0	0	0	0
TYPE 68-2	0	0	0	0	0	0
TYPE 68	2.013422819	54.50980392	1.234567901	0	14.67181467	0.204918033
TYPE 61	0	0	0	0	0	0
TYPE 62-2	0	0	0	0	0	0
TYPE 62	0	0	0	0	0	0
TYPE 58	0	0	0	0	0	0
TYPE 70	0	0	0	0	0	0
TYPE 71	0	0	0	0	0	0
TYPE 72	0	0	0	0	0	0
TYPE 73	0	0	0	0	0	0
TYPE 64	0	0	0	0	0	0
TYPE 76	0	0	0	0	0	0
TYPE 78	0	0	0	0	0	0
TYPE 79	0	0	0	0	0	0
TYPE 81	0	0	0	0	0	0
TYPE 89	0	0	0	7.737226277	0	0
TYPE 88	0	0	0	0	0	0
ROSACEAE	0	0	0	0.145985401	0	0

B.

Appendix B: Environmental Constraint Data

	A	B	C	D	E	F
1	ID	Lat	BP	Ele	Fog	Dist
2	57-4 Top	23.21	140	626	0.011111	7711.54451
3	57-4 Bottom	23.21	140.9	626	0.011111	7711.54451
4	79-2c	20.987	0	566	0	2654.58449
5	38-2 Top	25.684	1512	607	NA	NA
6	61-2	24.865	0	619	0.002895	10657.8297
7	48-1 Top	25.431	0	625	NA	NA
8	67-4	17.555	NA	635	0	2958.90069
9	38-2 Bottom	25.684	1512.9	607	NA	NA
10	61-1	24.865	0	619	0.002895	10657.8297
11	48-1 Bottom	25.431	0	625	NA	NA
12	67-3	17.555	NA	635	0	2958.90069
13	79-1a	20.987	NA	566	0	2654.58449
14	19	12.804	NA	391	0	4873.78609
15	18	12.854	NA	379	0.253763	6604.50433
16	83-1	24.138	0	539	0.007434	5097.68572
17	57-2	23.21	NA	626	0.011111	7711.54451
18	61-3	24.865	NA	619	0.002895	10657.8297
19	2--1	27.093	NA	607	0.011592	12880.5809
20	45-2	25.454	145	636	0.005324	9481.8378
21	103-2c	25.338	2765	646	0.003762	8868.43625
22	108-1B	23.123	145	658	0.011499	5169.95567
23	107-2B	23.11	142	669	0.011499	5144.86946
24	146	23.523	709	679	NA	NA
25	133-1A	23.05	141	674	0.014369	5030.73656
26	144-6	24	0	658	0.011728	7000.90232
27	143	24.074	0	669	NA	NA
28	155-F	24.513	4013	676	0.002914	7223.67187
29	155-D	24.513	3429	676	0.002914	7223.67187
30	153-2	23.843	395	670	0.007817	6712.61672
31	149-2	23.298	3251	674	0.005019	5828.51928
32	142-B	24.007	145	672	0.004514	6932.55377
33	145-4	23.733	1639	668	0.009859	6230.06172
34	135-3	14.618	NA	692	0.013939	450.215335
35	107-1	23.11	NA	669	0.011499	5144.86946
36	135-2	14.618	NA	691	0.013939	450.215335
37	155-2C	24.513	1449	676	0.002914	7223.67187
38	140	9.554	3468	1357	0.059807	4081.11108
39	144-4	24	141	658	0.011728	7000.90232
40	147-1	23.331	395	682	NA	NA
41	111-2E	23.142	1665	672	0.005815	5218.51833
42	151	23.305	1617	672	NA	NA
43	155-2B	24.513	677	676	0.002914	7223.67187
44	136-1	14.612	NA	701	NA	NA
45	138	23.15	1611	676	0.006173	5226.6225
46	152-1	23.938	0	676	0.011708	6881.18741

Appendix C: Carbon Dates + OxCal 3.9 Calibrations

Site ID	14C age	Calibration
57-4 Top	< 130	140
57-4 Bottom	130	140.9
79-2c	modern	0
38-2 Top	< 1570	1512
61-2	modern	0
48-1 Top	modern	0
67-4	XXX	NA
38-2 Bottom	1570	1512.9
61-1	modern	0
48-1 Bottom	modern	0
67-3	XXX	NA
79-1a	XXX	NA
19	XXX	NA
18	XXX	NA
83-1	modern	0
57-2	XXX	NA
61-3	XXX	NA
2--1	XXX	NA
45-2	160	145
103-2c	2940	2765
108-1B	110	145
107-2B	140	142
146	800	709
133-1A	120	141
144-6	modern	0
143	modern	0
155-F	3690	4013
155-D	2820	3429
153-2	340	395
149-2	3030	3251
142-B	100	145
145-4	1740	1639
135-3	XXX	NA
107-1	XXX	NA
135-2	XXX	NA
155-2C	1540	1449
140	3230	3468
144-4	130	141
147-1	1580	395
111-2E	1760	1665

151	1690	1617
155-2B	510	677
136-1	XXX	NA
138	1680	1611
152-1	modern	0